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Electrically activatable valve

The invention relates to an electrically activatable valve in accordance with the precharacterizing clause of Claim 1.

Electrically activatable valves which are actuated by electromagnets, piezoelectric elements and the like are used, inter alia, in fuel injection systems for internal combustion engines. Here, a feed pump feeds the fuel at a low pressure to the inlet side of a high-pressure pump, generally a mechanically driven piston pump, which injects the fuel at high pressure into the internal combustion engine via an injection valve. The quantity of fuel injected per operating cycle is limited by an electrically activatable valve establishing the connection between the pressure line of the injection pump and a return passage and thus ending effective delivery by the injection stroke.

A valve of the generic type belonging to an injection system is known from DE 34 06 198 C2. The electromagnetically actuable valve has a valve seat, a valve stem with a guiding part, a valve member in the form of a valve plate, an electromagnetic device and a valve spring. The valve stem is guided in an axially movable manner in a valve housing by means of a guiding part, an electromagnet pulling the valve member against a valve seat by means of an elastic element, counter to the force of the valve spring, in the excited state and the valve spring opening the valve member by a limited amount in the de-energized state of the electromagnet. The fuel is fed to the valve via a pressure passage which opens into an annular space between the valve seat and the guiding part. To ensure that no hydraulic forces, if any, act on the valve due to the fuel pressure, the

guiding part has, in the direction of the annular space, an offset, the annular area of which corresponds essentially to the hydraulically effective diameter of the valve member, with the result that the pressure forces acting on the valve member cancel each other out at the valve stem.

Owing to wear due to solid particles in the fuel and cavitation and to settling phenomena at the valve seat, the effective hydraulic diameter changes in the course of time and the hydraulic equilibrium existing at the outset is no longer present. This can disrupt the operation of the valve to a considerable extent, with the result that precise discharge of the fuel is no longer assured.

DE 19 716 041 A1 has already proposed using geometrical measures to ensure that the effective hydraulic diameter is not increased or limited by wear and settling phenomena in comparison with the design condition. This is achieved, for example, by virtue of the fact that the valve member and the valve seat have only a slight overlap. As a result, the small contact area remains relatively constant, even in the case of wear. However, it has been found that flow conditions at the valve seat are affected unfavourably by these measures, with the result that an increase in cavitation can be expected or dynamic response during opening of the valve will be impaired.

The object on which the invention is based is to improve flow conditions in the region of the valve seat without the need to sacrifice the advantages described above. According to the invention, it is achieved by the features of Claim 1.

According to the invention, the contact area between the valve member and the valve seat is bounded at the outside by a step, which is adjoined by a guide surface. The step simultaneously limits the effective hydraulic diameter of the valve member, which thus remains constant over its

entire life. The guide surface adjoining the step can be configured in such a way that the fluid is diverted to a return passage in an optimum manner, thus avoiding cavitation and noise associated with it.

It is expedient if the step and the guide surface are formed directly on the valve member, e.g. by offsetting the region of the guide surface relative to the contact area on the valve member by shaping with or without machining. However, the step and the guide surface can also be provided on the valve housing. A combination of both measures is furthermore conceivable. These configurations are suitable both for proportional valves in which the opening stroke changes in proportion to a control variable and for switching valves, in which the valve member assumes just one defined closed or open position.

In switching valves, in which the opening stroke of the valve member is limited by a stop, it is expedient if the step is formed by the edge of the valve member, and a separate baffle element adjoins the edge of the valve member. The baffle element can be connected either to the valve housing, advantageously, for example, by means of guide vanes, or to the stop which limits the opening stroke of the valve member. In this arrangement, the guide surface adjoins the contact area of the valve member in the open position of the valve member, allowing a favourable flow pattern to form.

It is expedient if the space between the baffle element, the stop and the valve member which the valve member enters during the opening stroke is connected to the return passage by radially oriented drainage passages to ensure that no hydraulic reaction occurs during the opening of the valve member. The subclaims contain a number of variants on the embodiment of the drainage passages. A specific level of damping of the valve can be achieved through the dimensioning of the drainage passages.

Further advantages will emerge from the following description of the drawing. The drawing shows illustrative embodiments of the invention. The description and the claims contain numerous features in combination. The person skilled in the art will also expediently consider the features individually and combine them into worthwhile further combinations.

In the drawing:

Fig. 1 shows a schematic partial section through a valve according to the invention,

Fig. 2 shows an enlarged detail in accordance with the line II in Fig. 1,

Fig. 3-7 show variants of Fig.2.

An electrically activatable valve 1 can be activated by means of a device 3, which can be an electromagnet or a piezoelectric element. In the activated state, the device 3 acts counter to the force of a valve spring 4 on a valve stem 8 which is guided axially in a valve housing 2 by means of a guiding part 9. The valve spring 4 is accommodated in a spring chamber 5 and is supported at one end, via a washer 7, on the device, which is secured on the valve housing 2, and at the other end, via a spring plate 6, on the valve stem 8.

At the free end of the valve stem 8 there is a valve member 10 in the form of a valve plate which interacts with a valve seat 13 on the valve housing 2. A fluid, in the case of a fuel injection pump fuel, is fed to the valve 1 at high pressure via a pressure passage 12, which opens into an annular space 11 between the guiding part 9 and the valve member 10, and, in the open position shown, is drained off into a return passage 27. In this position, the valve spring 4 presses the valve member 10 against a stop 25.

As can be seen more clearly from Fig. 2, the valve member 10 overlaps the annular space 11 only slightly in the radial direction, resulting at the edge of the valve member 10 in a narrow contact area 14, which is bounded at the outside by a step 15. According to Figs 2-5 and 7, the step 15 is formed by the edge 17 of the valve member 10, while, in the embodiment according to Fig. 6, the step 15 is formed by an offset in the valve member 10. Adjoining the step 15 is a guide surface 16 which optimizes the flow of the fuel to the return passage 27. The guide surface 16 can be formed directly on the valve member 10 (Fig. 6) or be part of a baffle element 18. This can be firmly connected to the stop 25 or be formed in one piece with it. It is furthermore possible to connect it to the valve housing 2 (Fig. 7), this expediently being accomplished by means of guide vanes 26, which assist the action of the guide surface 16.

Formed between the valve member 10, the stop 25 and the baffle element 18 is a space 28 which is connected by drainage passages 21-24 to the return passage 27 in order to avoid an accumulation of the fuel in this space 28 when the valve 1 is opened. The drainage passages 21-24 can be of various configurations. Fig. 2, for example, shows a baffle element 18 which is firmly connected to the stop 25 and has drainage passages 19 between it and the stop 25. The valve member 10 furthermore has drainage passages 20 at the end, it being possible for these to be formed by slots or milled recesses.

In the configuration according to Fig. 3, the stop 25 has through drainage passages 21 which lead from the region of the valve member 10 to the return passage 27 via the region of the baffle element 18.

The drainage passages according to Figs 4 and 5 are formed by slots 24 or holes 22 in the baffle element 18, which is connected to the stop 25. In this

arrangement, the hole 22 extends right into the region of the end face of the valve member 10. Since, in the embodiment according to Fig. 7, the baffle element 18 is connected to the valve housing 2, the drainage passage 23 can be formed by an annular space between the baffle element 18 and the stop 25.

Since the embodiment according to Fig. 6 does not have a separate baffle element, no drainage passages are required here. The fuel can escape between the end face of the valve member 10 and the stop 25 into the return line 27. In doing so, it does not hinder flow in the region of the valve seat.